

# A link between the hiatus in global warming and North American drought

*Thomas L. Delworth, Fanrong Zeng, Gabriel Vecchi, Andrew Wittenberg, and Anthony Rosati*  
GFDL/NOAA

- 1. Observed hiatus – or is that term still valid?**
- 2. Role of Pacific decadal-scale wind stress changes for:**
  - a. Pacific ocean changes**
  - b. Atmospheric changes, connection to North American decadal-scale drought**
- 3. Summary, discussion, unresolved issues**

Kosaka and Xie (Nature, 2013):

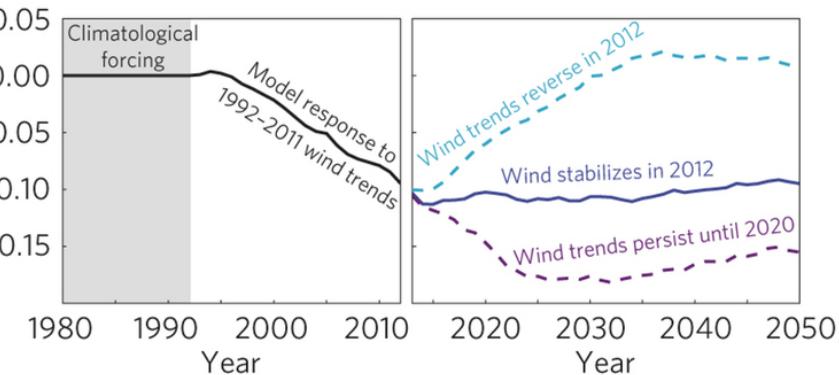
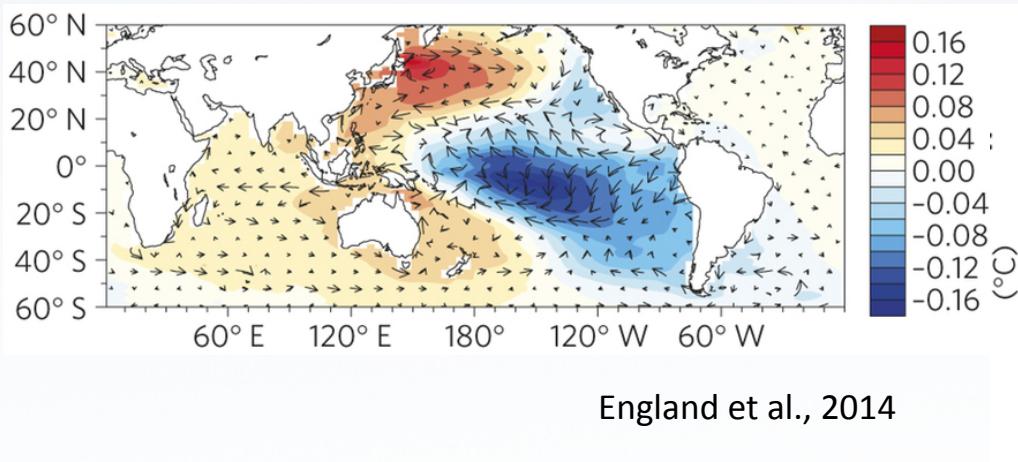
***"Recent global warming hiatus tied to equatorial Pacific surface cooling"***

- A global coupled model can reproduce the hiatus when given observed equatorial Pacific SSTs.

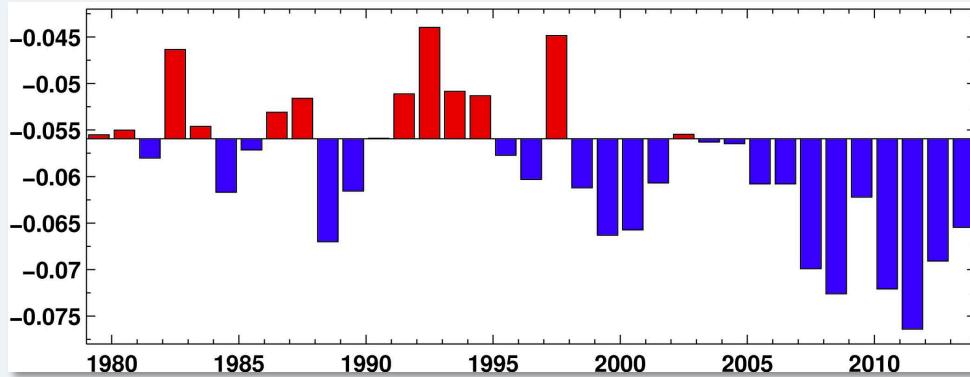
England et al (Nature Climate Change, 2014):

***"Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus"***

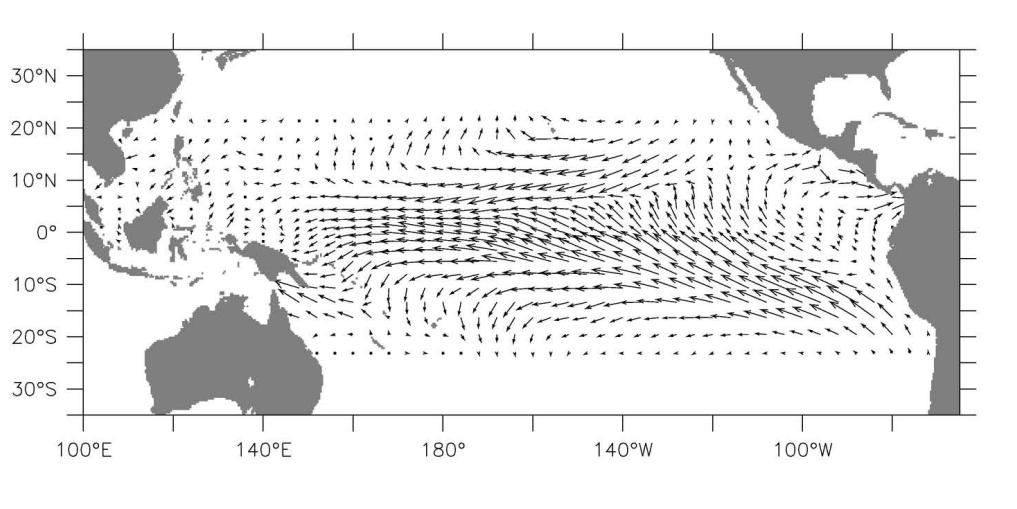
- Decadal-scale enhancement of easterly wind stress in the Pacific leads to upwelling and prolonged cooling in the tropical Pacific, with global-scale impacts



N m<sup>-2</sup>



Time series of annual mean wind stress in central Pacific [ECMWF-Interim]



Spatial pattern of wind stress differences: 2002-2012 minus 1979-1996 [ECMWF]

**Goal:** Evaluate the climatic impact of observed interannual to decadal variations in tropical Pacific wind stress

### Use three coupled models:

**CM2.1:** 100 Km ocean, 200 Km atmosphere

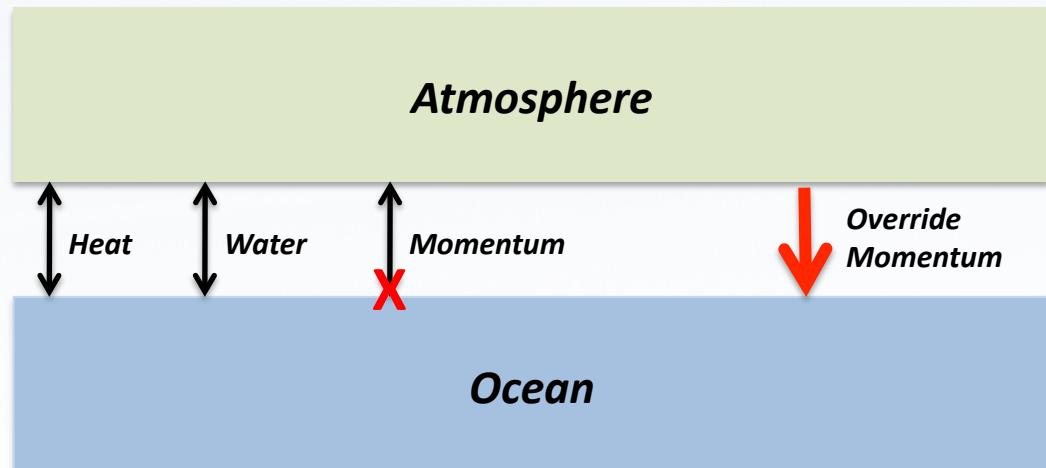
**FLOR:** 100 Km ocean, 50 Km atmosphere

**FLOR\_FA:** 100 Km ocean, 50 Km atmosphere (uses flux adjustments to reduce bias)

**Ensemble 1:** Historical radiative forcings (ALLFORC)

**Ensemble 2:** Historical radiative forcings PLUS observed wind stress anomalies (ALLFORC\_STRESS)

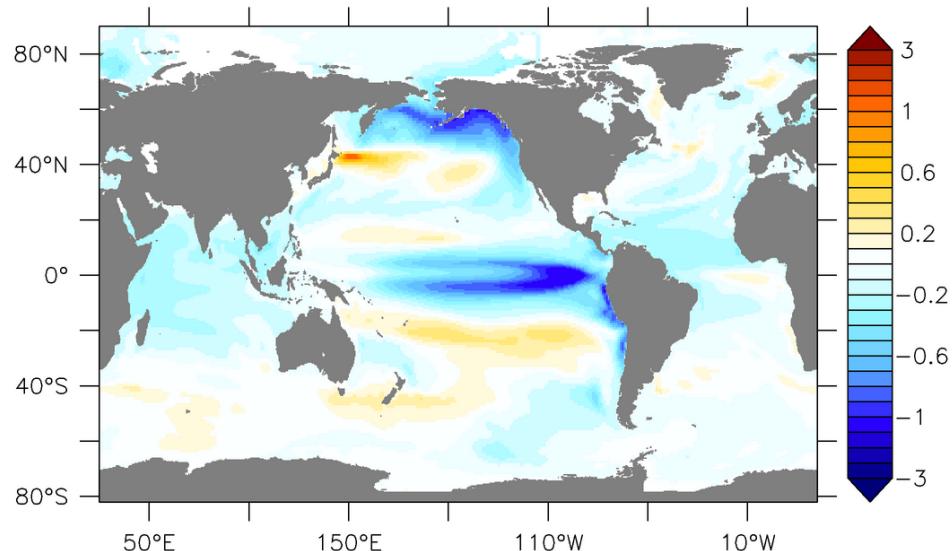
Simulations conducted over 1979-2012.



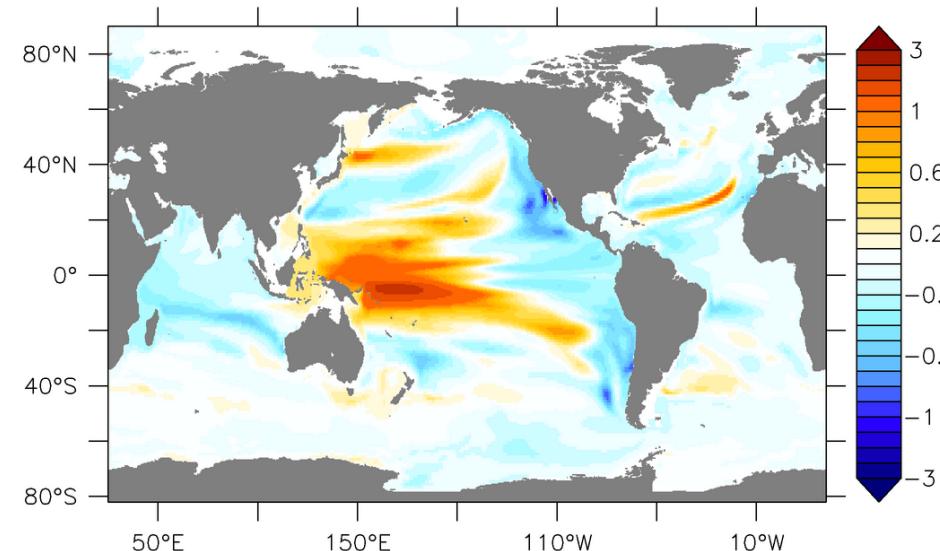
## Temperature response to wind stress forcing

2002-2013 minus 1979-2000

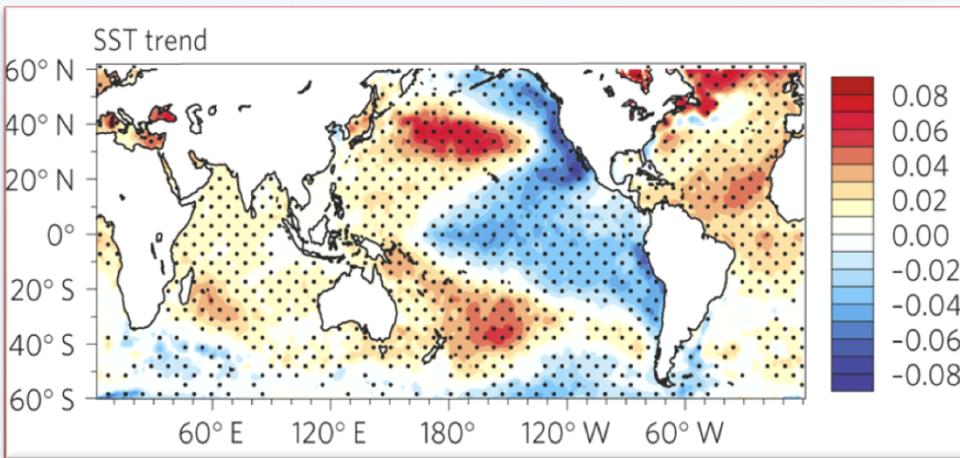
*Surface temperature response*



*Subsurface (200 m.) temperature response*

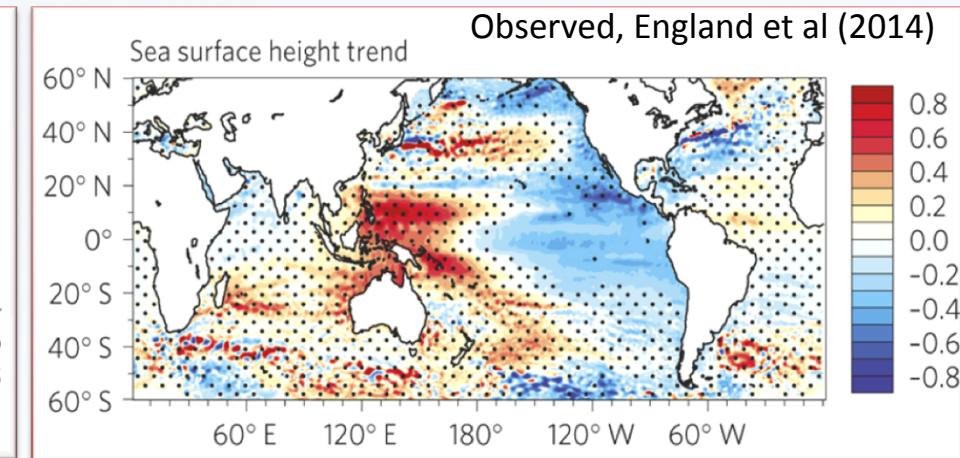


SST trend

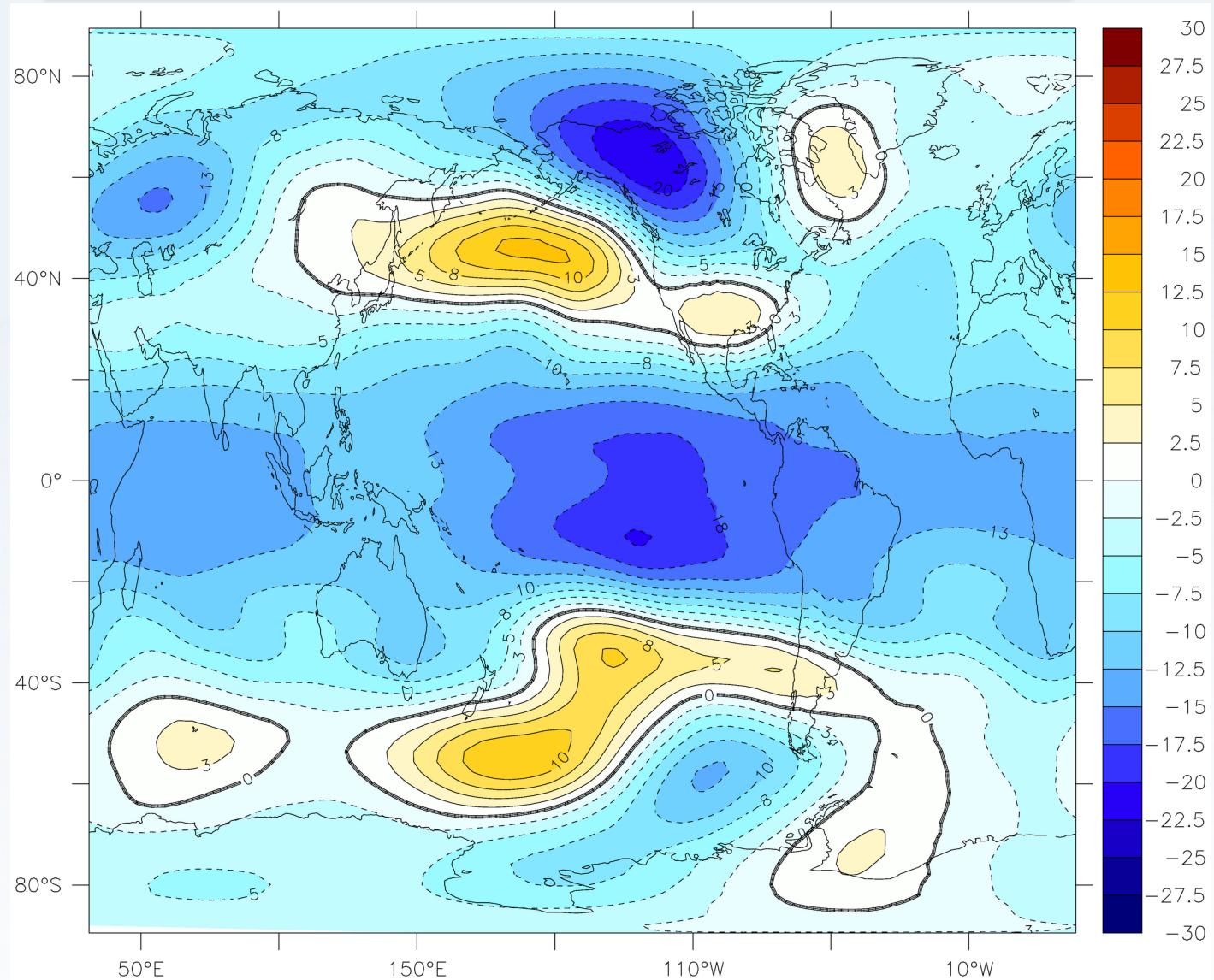


Observed, England et al (2014)

Sea surface height trend

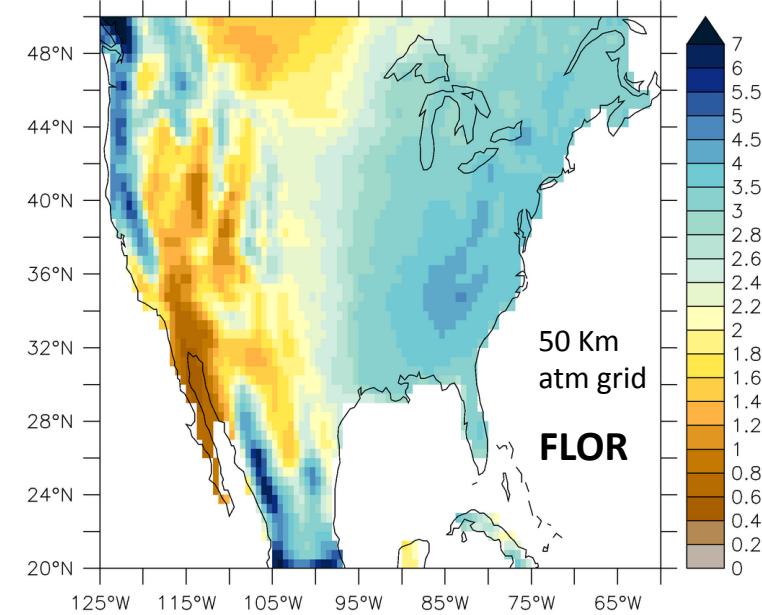
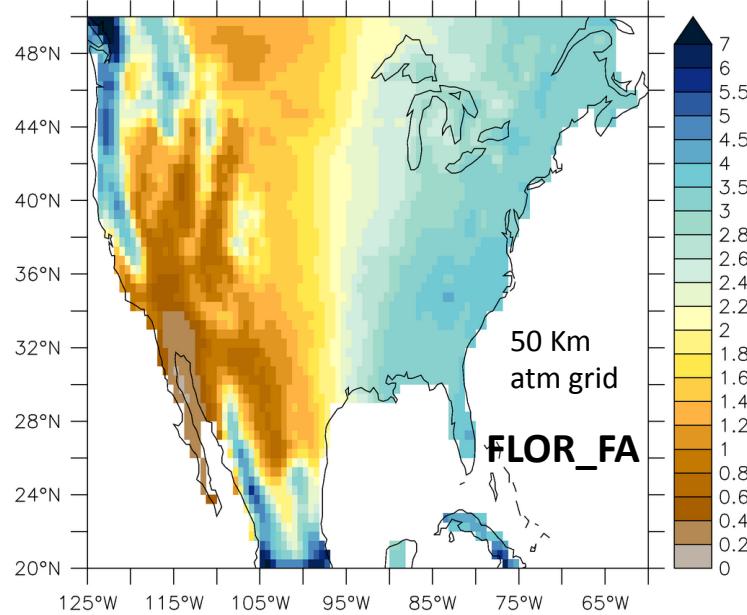
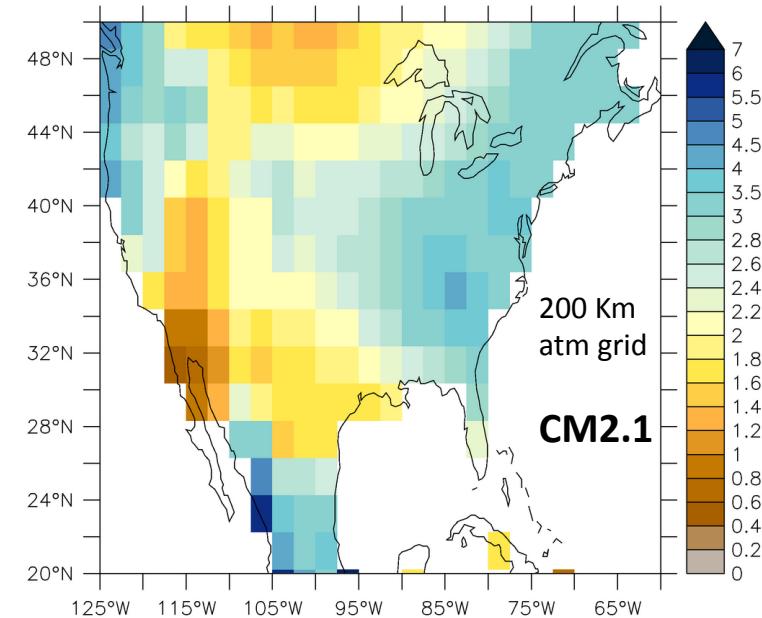
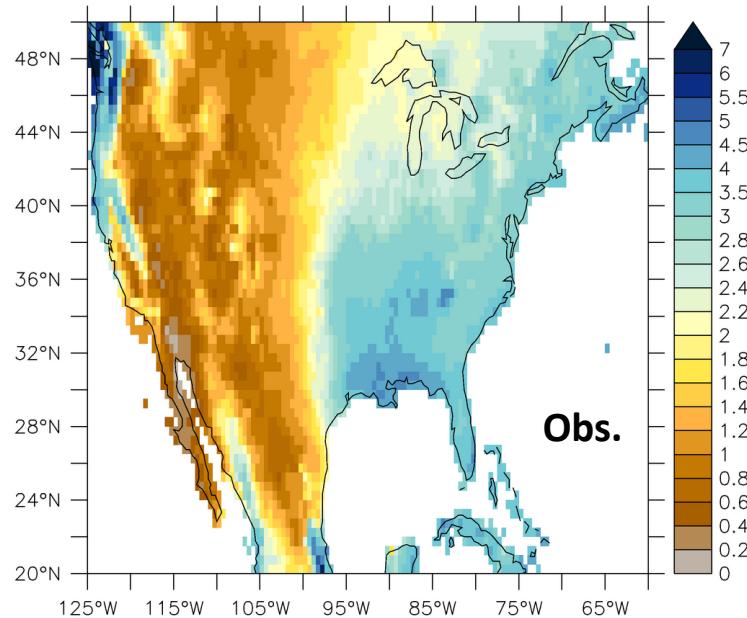


## What is the connection to North American drought?

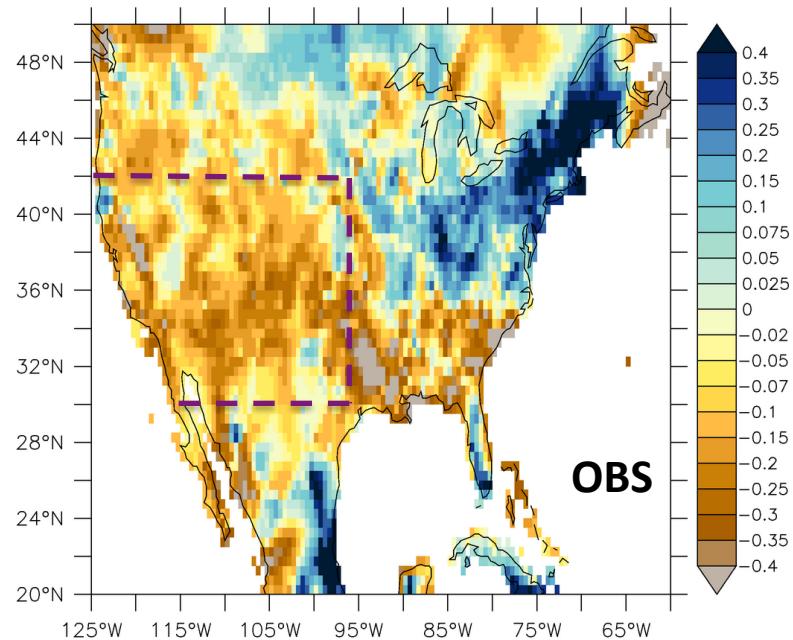


Difference in upper atmosphere geopotential height (pressure)  
in response to extra tropical Pacific winds (blue means lower heights/pressure)

## Observed and simulated annual mean precipitation ( $\text{mm day}^{-1}$ )

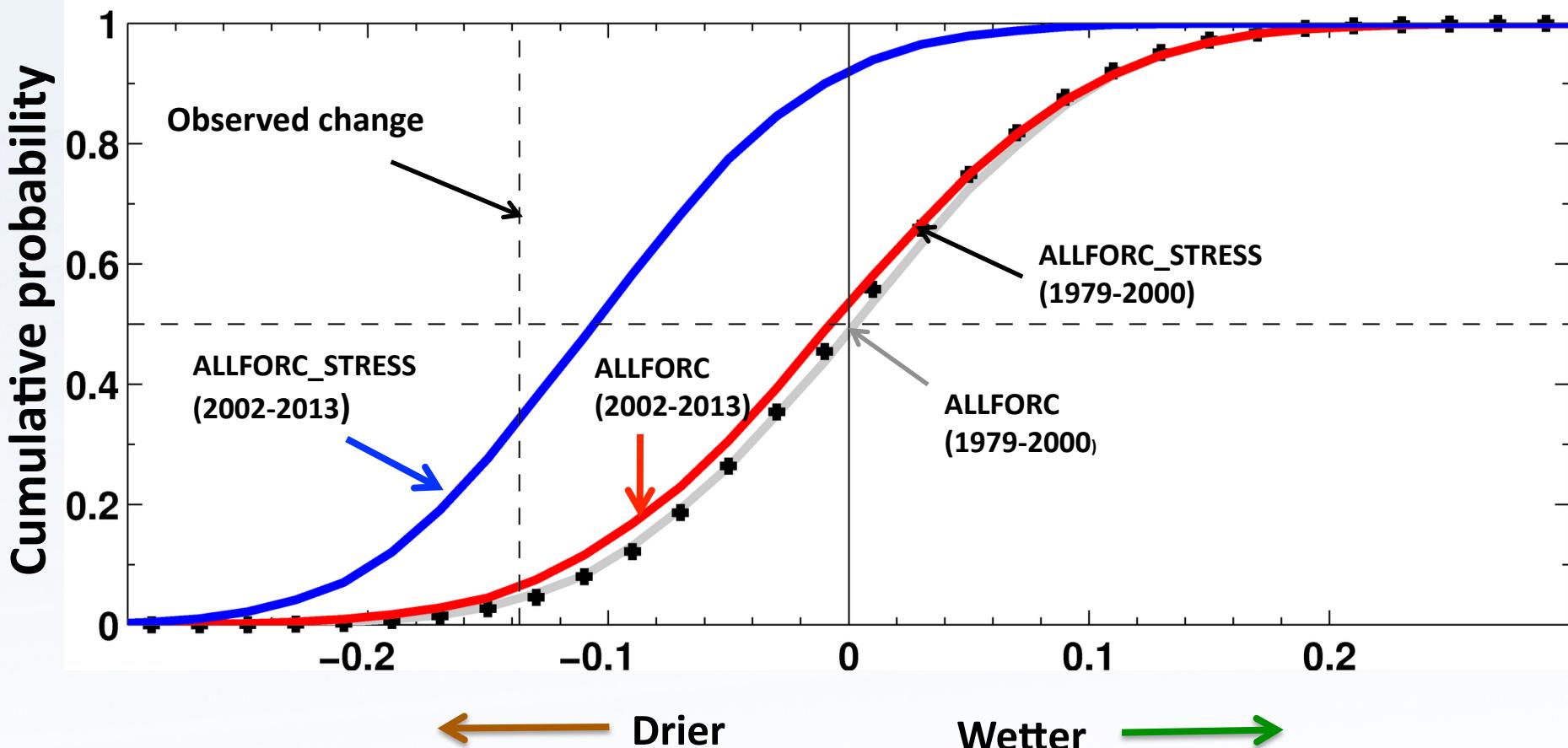


# Difference in annual mean precipitation: 2002-2012 minus 1979-2000



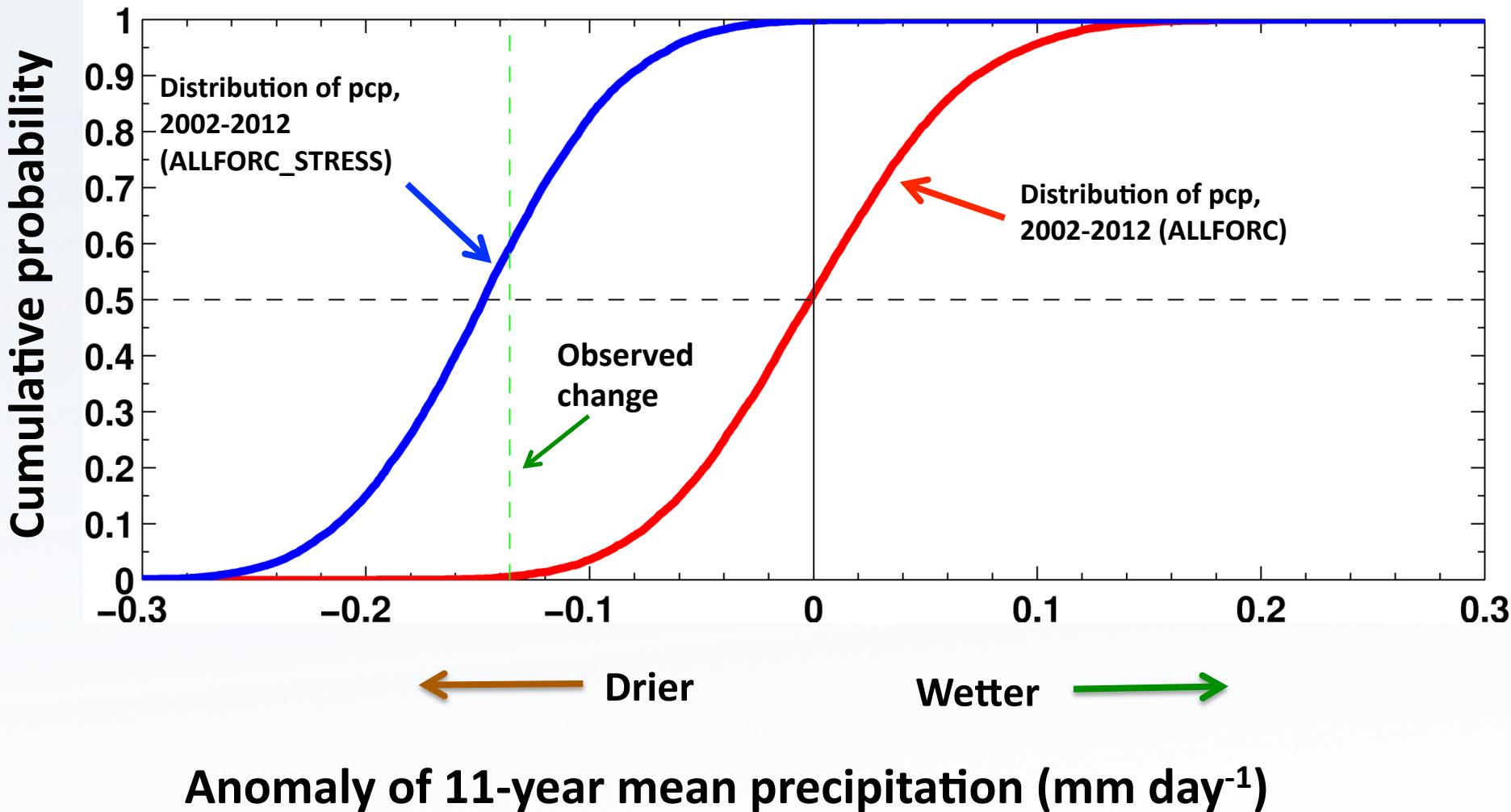
units:  
mm day<sup>-1</sup>

Probabilistic assessment of effects of tropical Pacific wind stress and radiative forcing on western North America annual mean precipitation  
(using 3 models: CM2.1, FLOR, FLOR\_FA)



Anomaly of 11-year mean precipitation ( $\text{mm day}^{-1}$ )

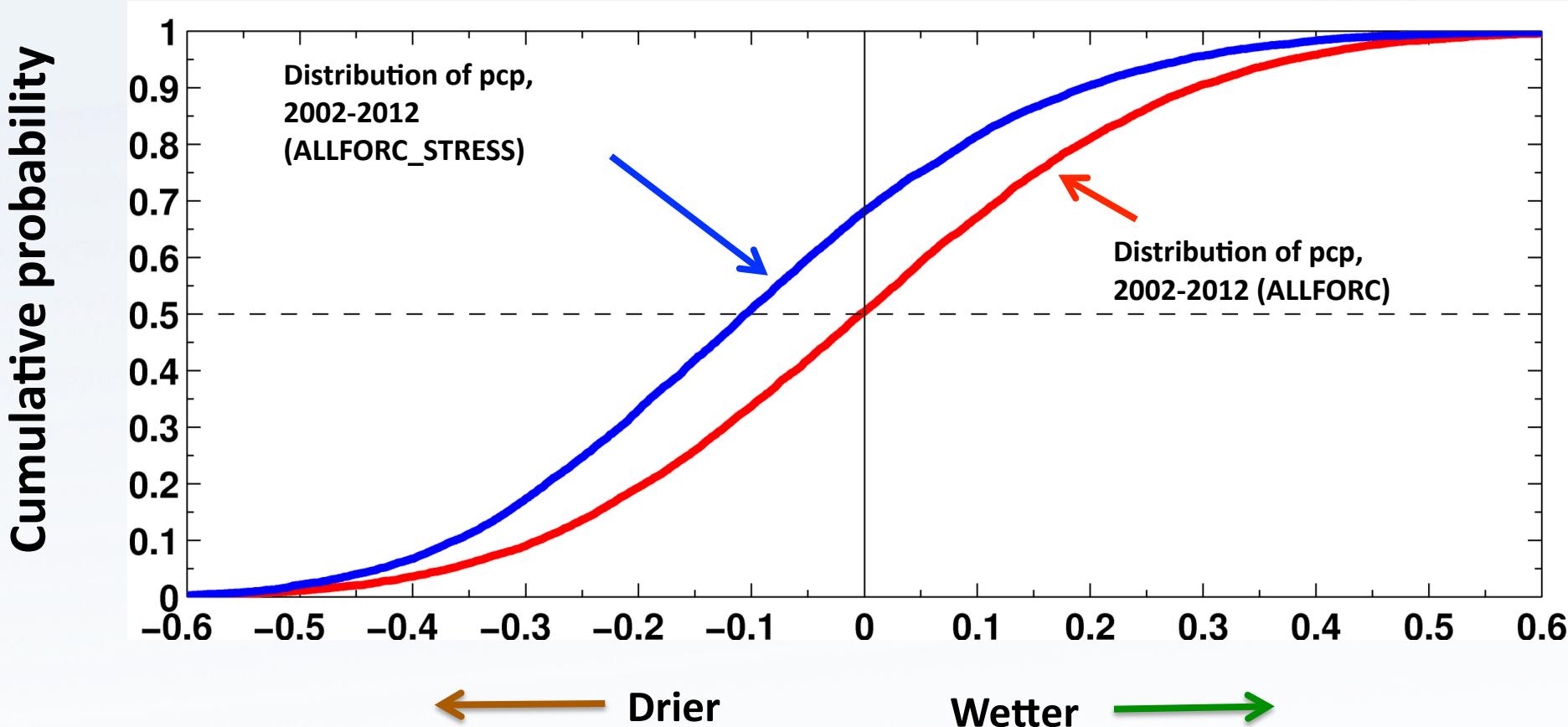
Probabilistic assessment of effects of tropical Pacific wind stress and radiative forcing on western North America annual mean precipitation  
(using only model FLOR\_FA, 30 member ensembles)



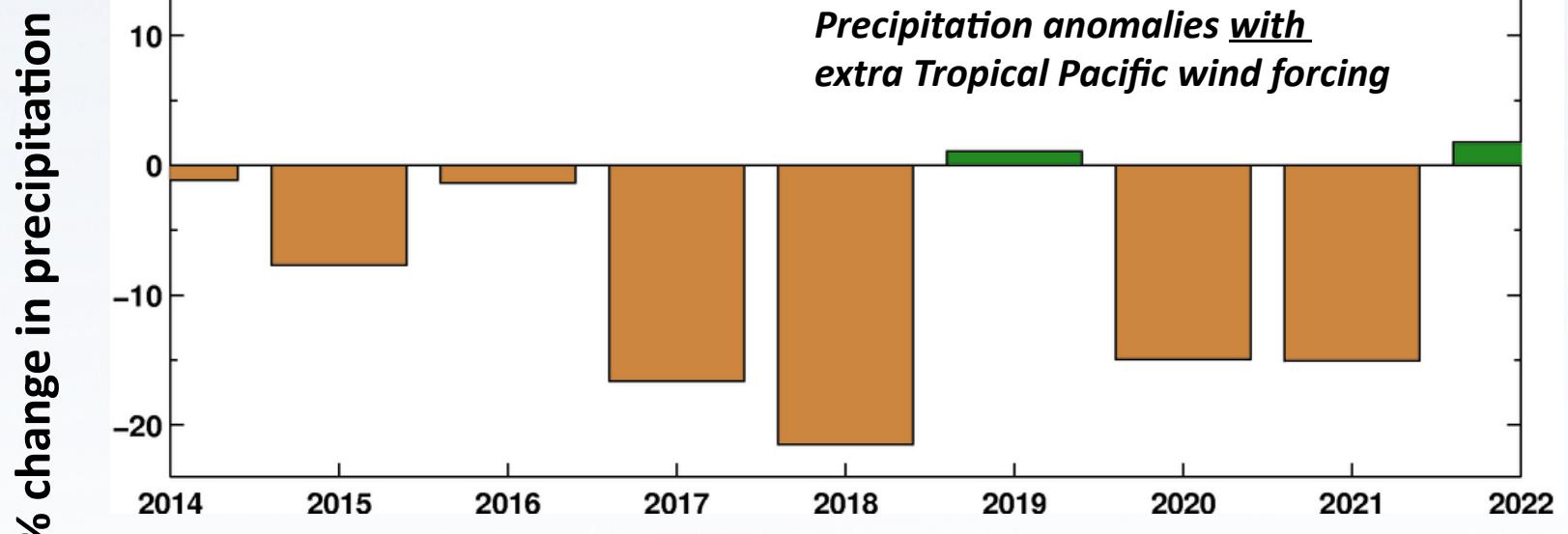
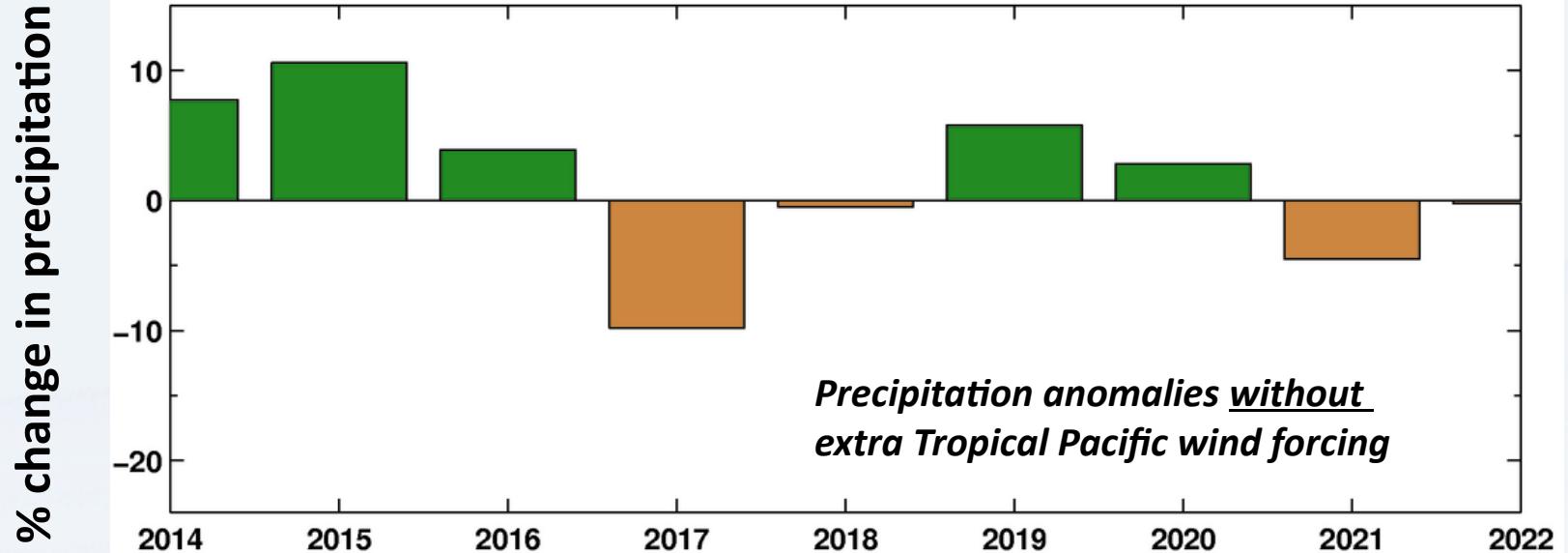
Probabilistic assessment of effects of tropical Pacific wind stress and radiative forcing on California annual mean precipitation  
(using only model FLOR\_FA, 30 member ensembles)

Smaller region, shorter time scale →

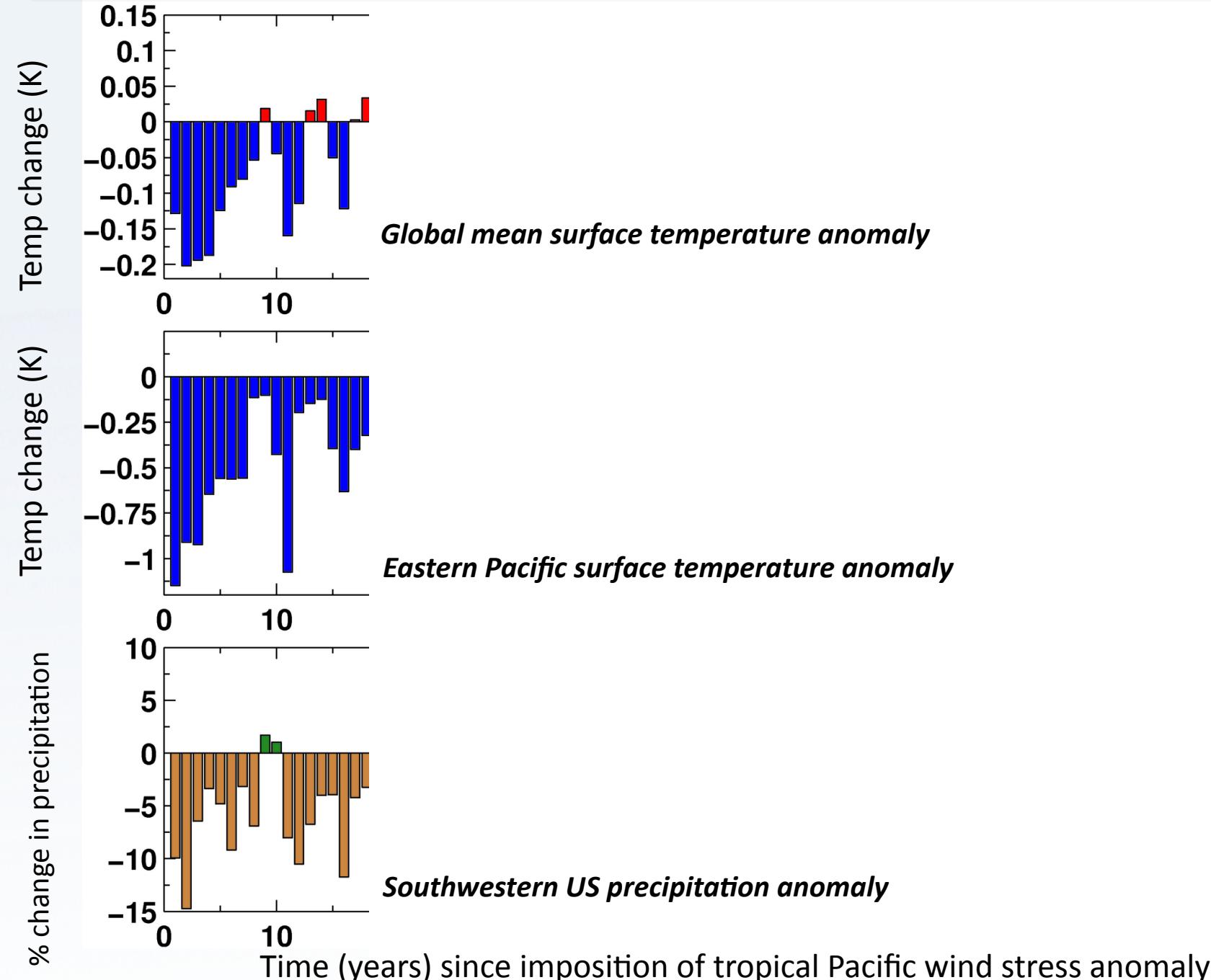
less impact from tropical Pacific, larger role for internal variability



Anomaly of 3-year mean precipitation (mm day<sup>-1</sup>)



## *Response of climate system to addition of uniform, constant easterly wind stress in tropical Pacific*



## Concluding Points

1. Prolonged, unusually strong tropical easterly winds contribute to tropical Pacific - and global - surface cooling [Kosaka and Xie, 2014; England et al., 2014]
2. This process also leads to substantially increased odds of drought over western North America [Delworth et al., 2015]
3. In idealized simulations with constant easterly wind stress anomaly, the "hiatus effect" is temporary  
→ re-emergence of warm anomalies after a decade or two offsets the initial cooling

## Some Key Issues

1. What drives the anomalous easterly winds?
  - Natural variability involving the Pacific and/or Atlantic oceans? (McGregor et al, 2014)
  - Anthropogenic or natural radiative forcing?
2. Can we predict the evolution of such tropical winds and their impact on North American drought?
3. Large component of natural decadal variability of hydroclimate over western North America – needs to be understood when considering human impacts